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## Chapter 4

# Digital Terrain Modeling

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## 4.1 Objectives

- Understand Digital Terrain Models (DTM's)
- Learn how to analyze a digital terrain model

## 4.2 Definitions

A **Digital Terrain Model (DTM)** represents the topography of a project in the form of a triangulation network. The DTM can be drawn in a three-dimensional file, and rotated to see the existing surface of the project area.

Digital Terrain Models can be generated from various sources including Microstation Elements, survey data, photogrammetry data, **GEOPAK** cross-sections, and geometry data.

**Triangulation** is a mathematical process applied to stored elevation points and stored elevations along DTM break lines to create surfaces. The result of triangulations is the creation of a .tin file from which original ground profiles and original ground cross sections can be generated.

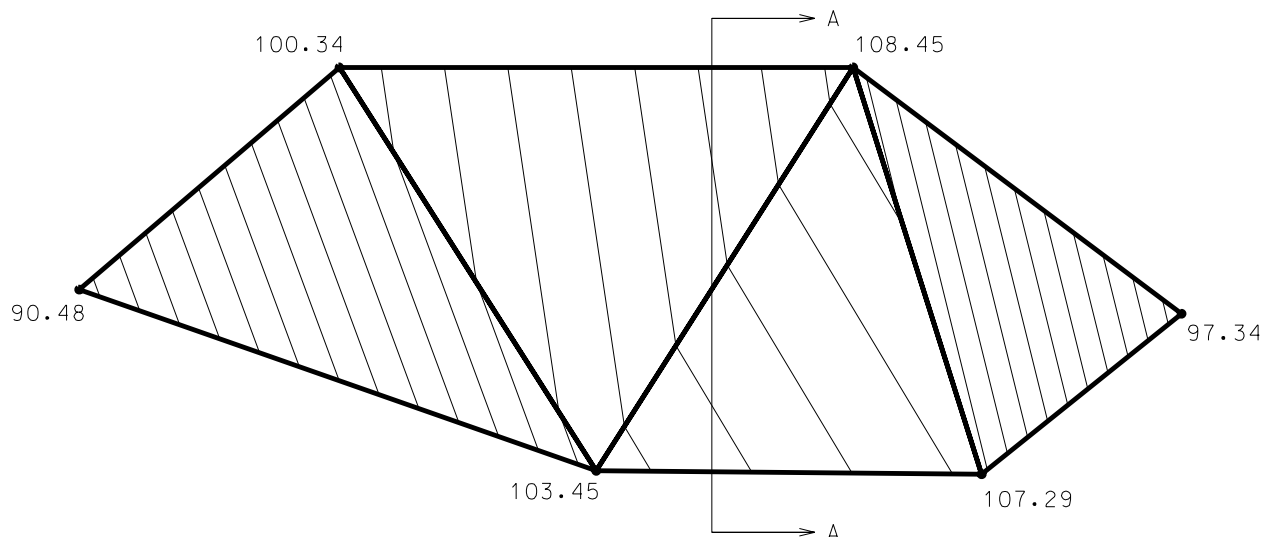
### 4.2.1 Digital Terrain Models

**Digital Terrain Models (DTM)** are made up of a network of triangles. A triangle is used because three points define a particular plane in space. This triangle then represents a slope on the existing ground passing through these three points.

The DTM is made up of several types of elements including points, breaklines, boundary, voids, and islands.

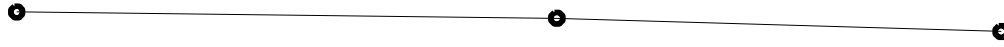
#### 4.2.1.1 POINTS

Points represent a particular location with an X, Y, and Z coordinate. Each of these points will represent a vertex on a triangle in the digital terrain model. Below is an example of a digital terrain model made from a set of points.



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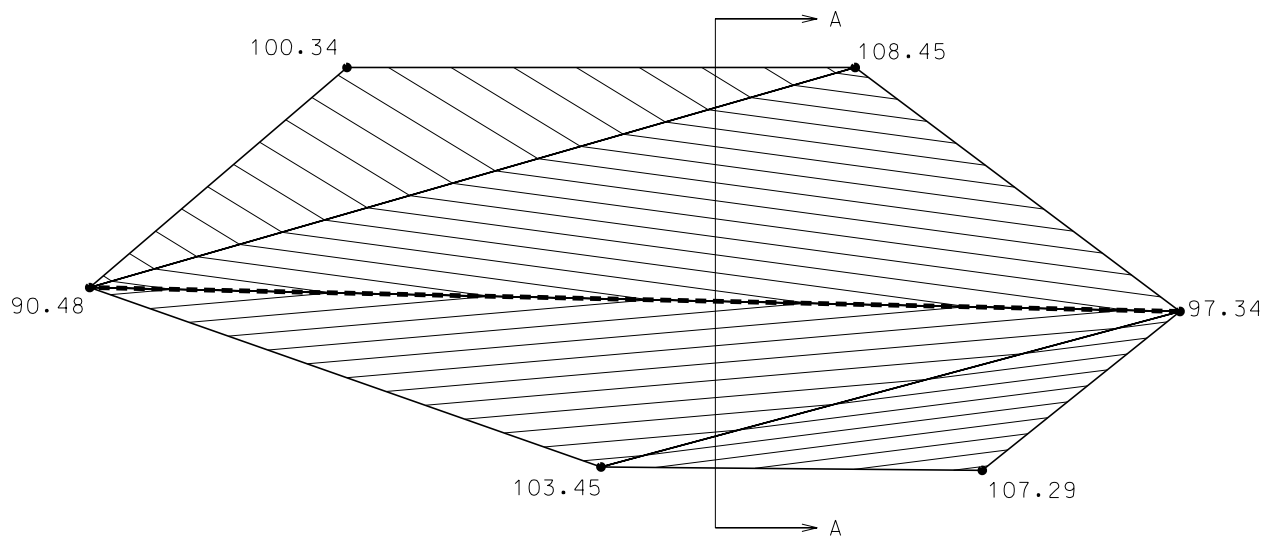
If a section is cut through this digital terrain model at the location A-A, where the elevation of the triangle leg as linearly interpolated between the triangle vertices is plotted along the distance of the section, the section would look as shown in the picture below.



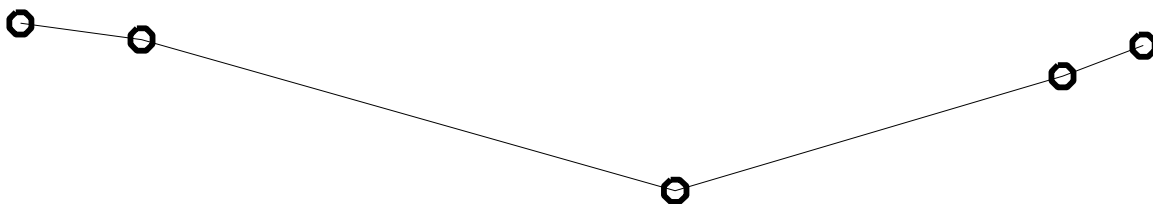
### 4.2.1.2 BREAKLINES

Breaklines represent a line along a change in slope. Examples of breaklines may include the edge of shoulder, the toe of a slope, or the flow line of a ditch. A triangle cannot cross a breakline. If a triangle crosses a breakline, it is split into multiple triangles so that no triangle leg will cross the breakline, and the triangles adjacent to the breakline will have a leg that lays on the breakline.

Adding a breakline to the same set of points used above will produce the digital terrain model as shown below.



Cutting a section at the same location will produce very different results as shown in the section below.

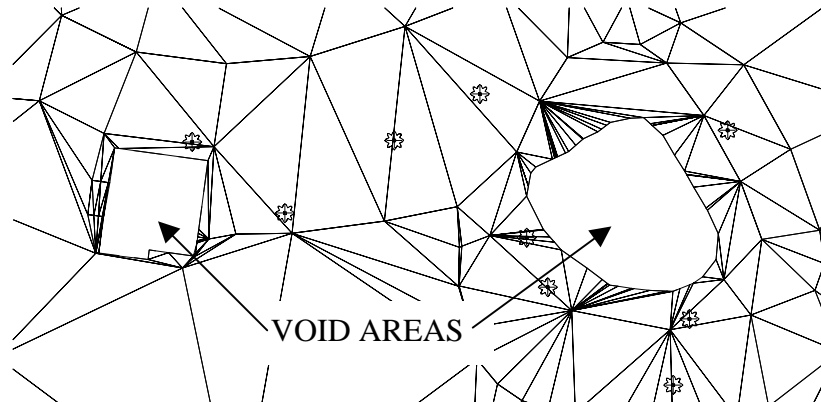


### 4.2.1.3 BOUNDARY

A boundary is the maximum external limits a digital terrain model can extend. No triangles will be created outside of this boundary.

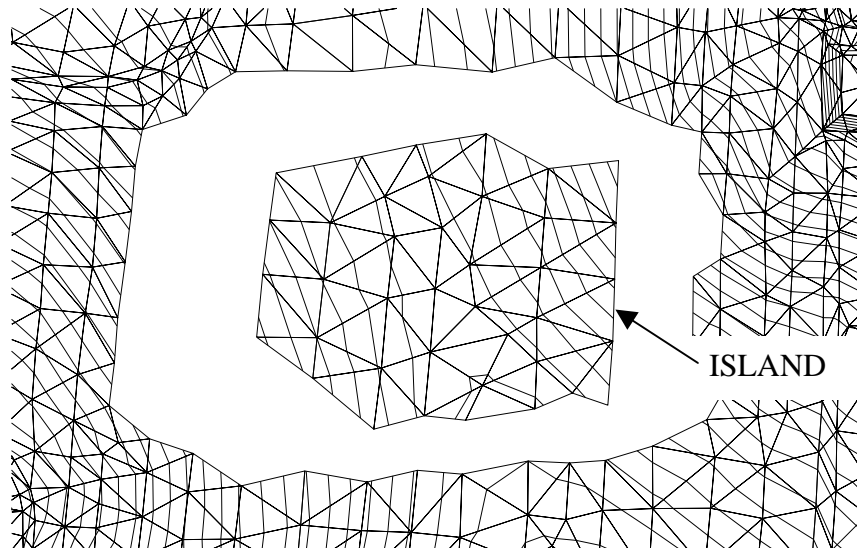
### 4.2.1.4 VOIDS

A void is an area where no contours can pass through. Examples of voids include ponds, lakes, buildings, concrete pads, etc.



### 4.2.1.5 ISLANDS

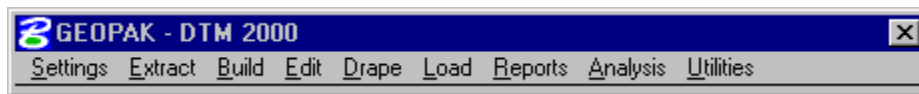
An island represents an area inside a void that contains contours.



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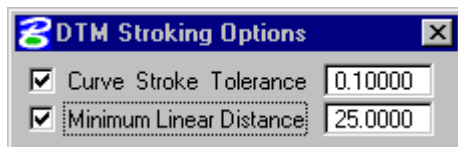
### 4.3 Accessing

Selecting the Existing Ground push-button from Project Manager or the DTM Tools icon, and selecting a run will bring up the tool palette shown to the right. All of the DTM tools can be accessed from the tool palette or from the DTM menu that can be accessed from the first icon in the tool palette.



### 4.4 Settings

Two user-defined stroking values need to be defined before graphics can be extracted to create a DTM. Stroking is the process of automatically adding shots to the DTM Input file by interpolating new shots from the linear and curved sections of the data. If the source topography data is mapped in a 3D-design file, stroking may be applied. Stroking is not available if the topography data resides in a 2D-design file.

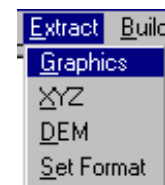


**Curve Stroke Tolerance** The maximum distance between the arc and the chord used to approximate the arc in the DTM.

**Minimum Linear Distance** If a linear segment is greater than the Minimum Linear Distance, points are interpolated and added to the segment such that the distance between the points is not greater than the Minimum Linear Distance.

### 4.5 Extract Graphics

The Extract Parameters tool translates Microstation elements into DTM input data. The dialog box shown below can be accessed from the GEOPAK DTM pull down by single clicking **Extract >> Extract Graphics** or from the Extract Graphics icon in the DTM toolbox.



**File Name** specifies the name of the file to be created for storing the input data. If file already exists, it may be found using the **Files** button.

**File Type** specifies the format of the new file. Either format will produce the same results. The difference between the two is ASCII files can be viewed and edited with a text editor while Binary files process faster. For ASCII files, the number of decimal places can be chosen.

**File Open** indicates if you are creating a new file or appending data to an existing file.

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**Feature Type** determines the type of feature to extract from a design file.

**Spots** – random survey points. Can be vertices of a line or line string.

**Breaks** – designate linear features such as edges of pavements, ditch bottoms, ridges, etc.

**Boundary** – the external boundary of the digital terrain model.

**Contours** – for use in extracting digitized or otherwise imported contours.

**Void** – closed shapes representing an area with no contours. (i.e. ponds, headwalls, concrete pads, etc.)

**Islands** – an area within a void that contains contours.

**Graphic Triangles** – for use in extracting triangles from a TIN model that has been otherwise created or imported.

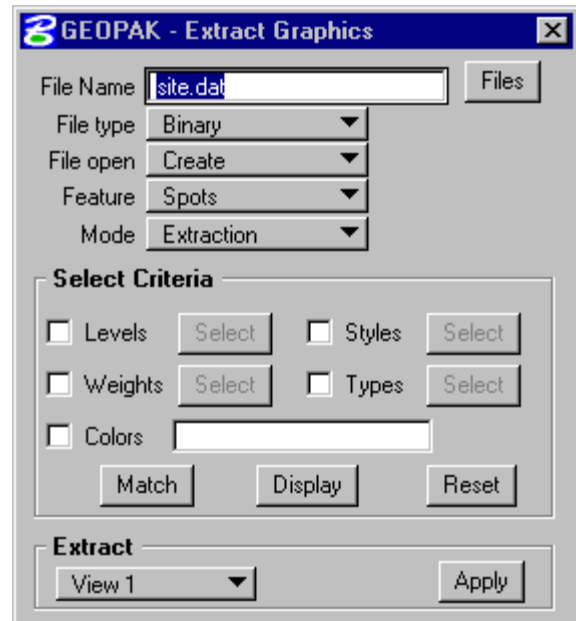
**Drape Void** – same as void, except uses the elevation from the triangulated model.

**Break Void** – same as void except edges are inserted as breaklines instead of drapelines.

**Mode** the extraction mode calculates XYZ data directly from the coordinate values of 3D Microstation elements. The interpolation mode produces XYZ data by interpolating between spot elevations along linear Microstation elements. This mode works in both 2D and 3D files.

**Select Criteria** provides ways to specify the features to be extracted. When an “X” is placed in the box next to Levels, the Select box is activated. You may then click the Select button to indicate only those levels you want GEOPAK to search for when extracting data. If the Levels box is not turned on, GEOPAK will search all levels. The same procedure is true for the other criteria selections. The three buttons located at the bottom of the **Select Criteria** group box **Match**, **Display**, and **Reset** will assist you in interactively defining the search criteria.

**Extract** there are four options for data extraction. **Complex Chain** reads those elements along adjoining Microstation elements. **Selection Set** uses a Microstation



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Selection Set to define elements for extraction. **Fence** will extract all elements within a fence boundary. **View 1** etc. will extract all the elements displayed in the selected view.

### 4.6 Build



Included under the **Build** pull down and icons are options for creating, manipulating, and merging DTM models.



#### 4.6.1 Build Triangles

**Build>>Triangles** processes the information stored in a DTM input file (.dat) to create a triangulated model (.tin). The file extension represents a triangular irregular network.



**Data File** is the name of the DTM input file where the extracted topological features are stored.

**TIN File** is the name of the file in which the triangulated model will be stored in binary format.

In either of the above cases, you do not have to enter the file extension with the file name and you can always navigate to an existing file using the **Files** button.

The **Dissolve Option** eliminates external triangles that are not representative of the surface. The three options are:

- None** – no external triangles are dissolved.

- Sliver** – long, thin triangles are dissolved.

- Side** – external triangles whose external side is longer than a user specified length are dissolved. (Recommended Option)



### 4.6.2 Additional Build Options

**Build >> Lattice** creates a grid (.lat) that can be draped over the triangulated data (.tin) to create a three dimensional visual display of the topography.

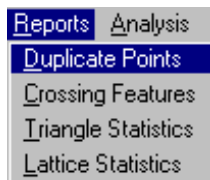
**Build >> Merge** allows two triangulated models to be merged together as long as the boundary of one model overlaps the other. This process will create a third model (.tin) from the combination of the two existing models.

**Build >> Clip** creates a new model (.tin) from a clipped portion of an existing model. The area is defined as internal or external to a user defined clip polygon.

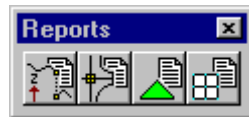
**Build>>Pad** defines a pad (such as a building slab) and integrates the pad into the existing terrain with a variety of slope options.

**Build>>Delta Surface** creates a new model based on the difference between two other models, or a model and elevation surface. The Z value in the model that is created is equivalent to the difference between the two specified models, or model and surface.

### 4.7 Reports



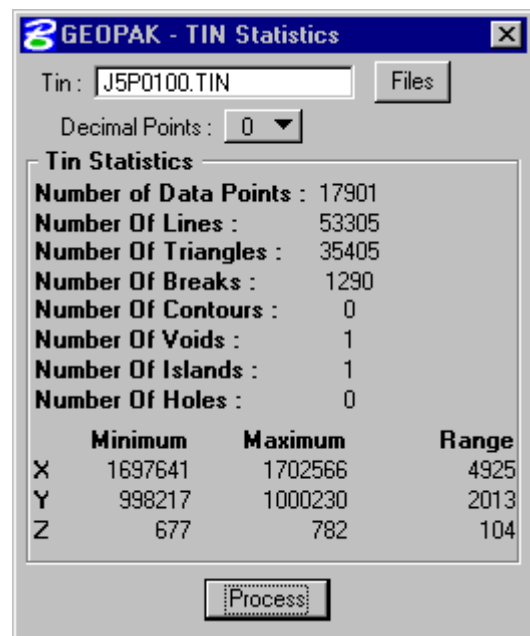
The options under the **Reports** pull down and icons include a way to check for duplicate points or crossing breaklines, and the ability to generate statistics associated with a .tin file.



**Duplicate Points** – reports points with the same x and y coordinates.

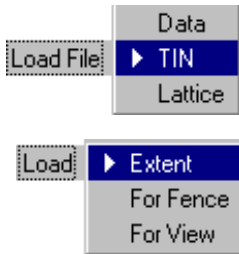
**Crossing Features** – reports intersecting breaklines or contours.

**Triangle Statistics and Lattice Statistics** - displays a summary indicating the total count of each element type and minimum and maximum X, Y, Z ranges for the specified .tin or .lat file.

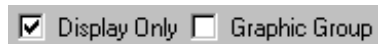




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The user can choose to load the DTM data (.dat), the TIN file (.tin), or the lattice file (.lat). Each of these files can be loaded for the model extents, within a fence, or within a window.



Toggling on **Display Only** will allow the user to view the elements without writing them to the Microstation file.

Conversely, toggling **Display Only** off will store the viewed elements as Microstation elements. If **Display Only** is on, updating the active screen will clear the display of these elements. When **Display Only** is off, the elements can be placed as a graphic group using the **Graphic Group** toggle.

Feature	Level	Color	Weight	Style	Display
Triangles	1	4	0	0	ON
Tin Hull	1	1	0	0	ON
Contours	-	-	-	-	ON
Major Lines	1	3	0	0	ON
Major Label	1	4	0	0	ON
Minor Lines	1	5	0	0	ON

1 [Green Box] [Line Style] [Line Style] [Checkmark]

The user can set what data to visualize, the symbology, and the contour interval (if **Contours** is turned on).



Will turn on all items.



Will turn off all items.



Will turn on only the selected item.



Will turn off only the selected item.

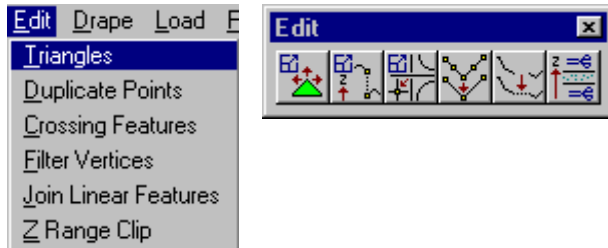
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## 4.10 Other Pull Down Menus

### 4.10.1 EDIT

The **Edit** pull down provides the ability to edit the digital terrain model.



**Triangles** - Allows the user to add, delete, or modify triangle vertices, triangle legs, and breaklines.

**Duplicate Points** – Reports and allows interactive editing of points in a survey data file with the same X and Y coordinates.

**Crossing Features** – Reports and allows the correction of crossing breaklines.

**Filter Vertices** – Reduces the amount of vertices by deleting the vertices based on a user specified distance.

**Join Linear Features** – Allows the user join two linear features into one feature.

**Z Range Clip** – Deletes information from the survey data file (.dat) based on given elevation information.



### 4.10.2 DRAPE

GEOPAK provides two tools for draping Microstation elements onto a triangulated model, vertices and vectors.

### 4.10.3 ANALYSIS



The **Analysis** tools allow the user to view the digital terrain model through many different methods such as a profile, themes, and drainage.

**Height** – Show the user the x, y, and z coordinates and the slope of a given data point. The contour at that elevation, the triangle the point lies within, and the direction of flow can be displayed.

**Profile** – Will display the profile of the digital terrain model between two points.

**Volumes** – Will calculate the volume between two TIN models, the volume between a TIN model and a plane, or the cut and fill totals between two TIN models.

**Elevation Differences** – Will display the elevation difference, or the amount of cut and fill between two TIN models, or a TIN model and a plane.

**Slope Area** – Displays the slope area of a TIN model, or a portion of a TIN model.

**Themes** – Displays the digital terrain model based on different user definable themes such as, elevation ranges, slope percentage, slope degree, or aspect.

**Drainage** – Allows a user to display and analyze drainage patterns within a TIN model. Tools include delineating watersheds, drawing flow arrows, determining upstream and downstream traces, and finding high and low points.

**Visibility** – Displays lines of sight (which triangles can and cannot be seen), or what is visible between two specified points.

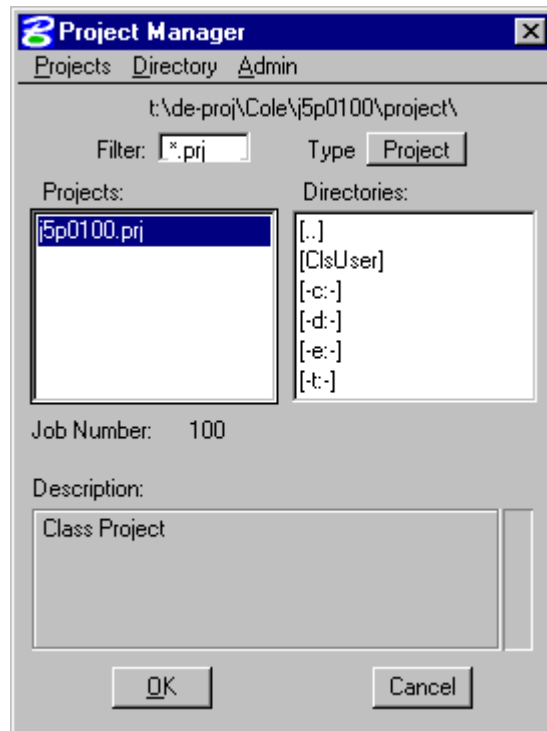
For more information on these items, see the *Geopak Manual* or online help.



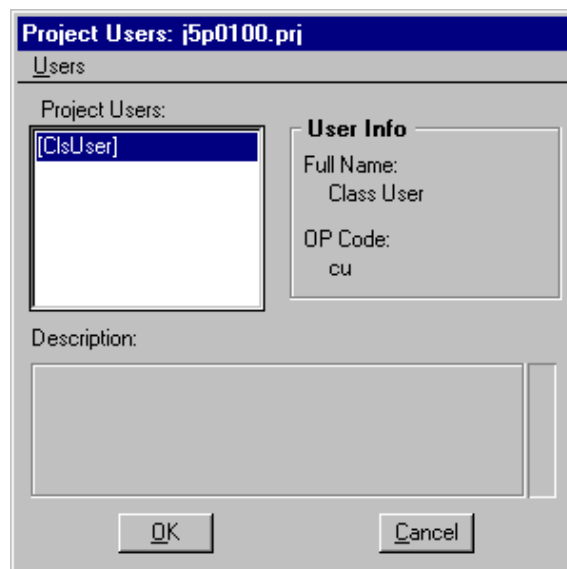
### 4.11 Exercise 4-1

1. Open the MicroStation file **t:\de-proj\cole\j5p0100\data\topo\_j5p0100.dgn**.

2. Open the project **j5p0100.prj**.

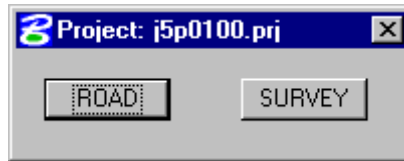


3. Select the user **ClsUser**.

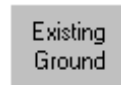


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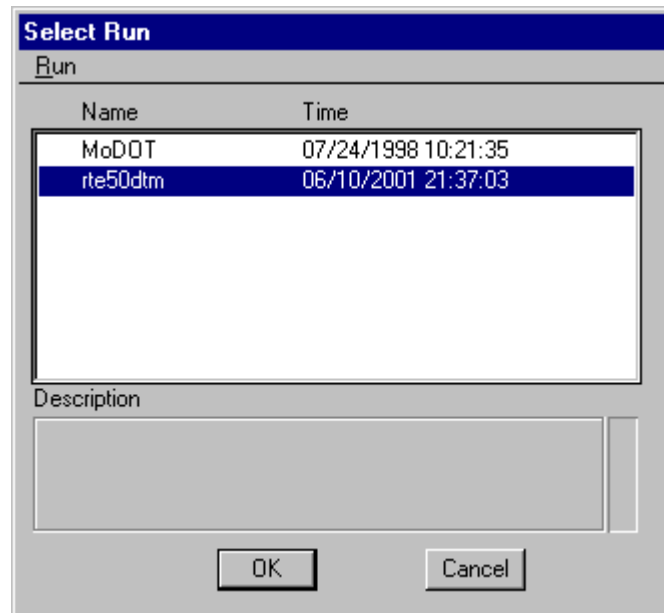
4. Select the **Road Project Manager**.



5. Select the **Existing Ground**.



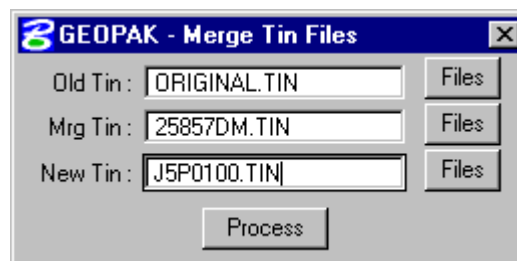
Copy the MoDOT run to **rte50dtm**, and open the **rte50dtm** run.



6. Use the **Build > Merge TINs** tool to merge the **25857dm.tin** with the **original.tin**.

Select the **original.tin** as the **Old Tin** and the **25857dm.tin** as the **Mrg Tin**.

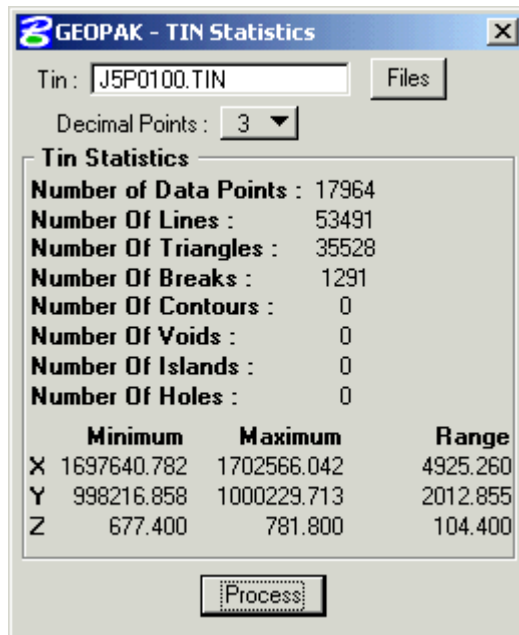
Set the **New Tin** to **J5P0100.TIN**



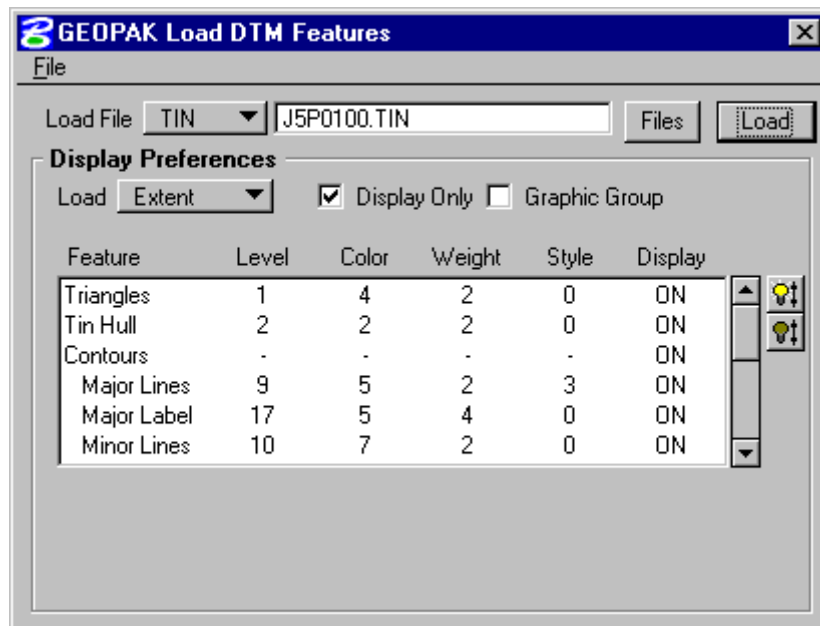


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7. Check the **Triangle Statistics (Reports > Triangle Statistics)** of the tin file **j5p0100.tin**.



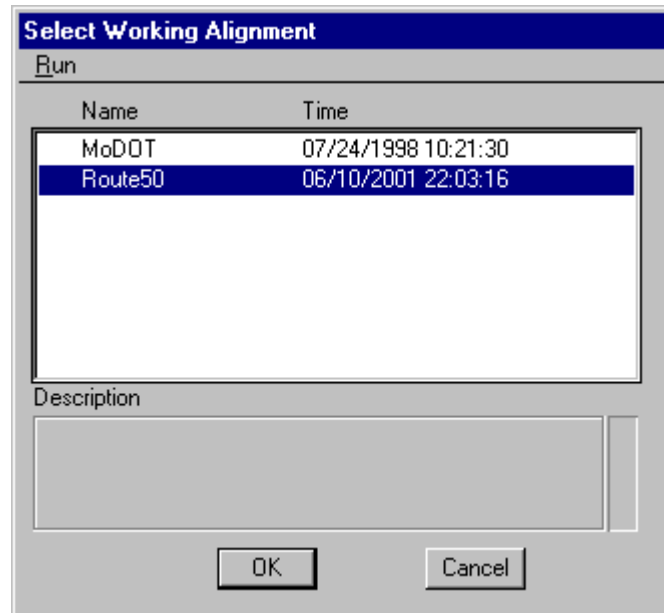
8. Load (**Load > DTM Features**) the triangles and contours into the view. Load them as **Display Only**.



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9. In the **Road Project** dialog choose the **Select** button to create a new **Working Alignment**.

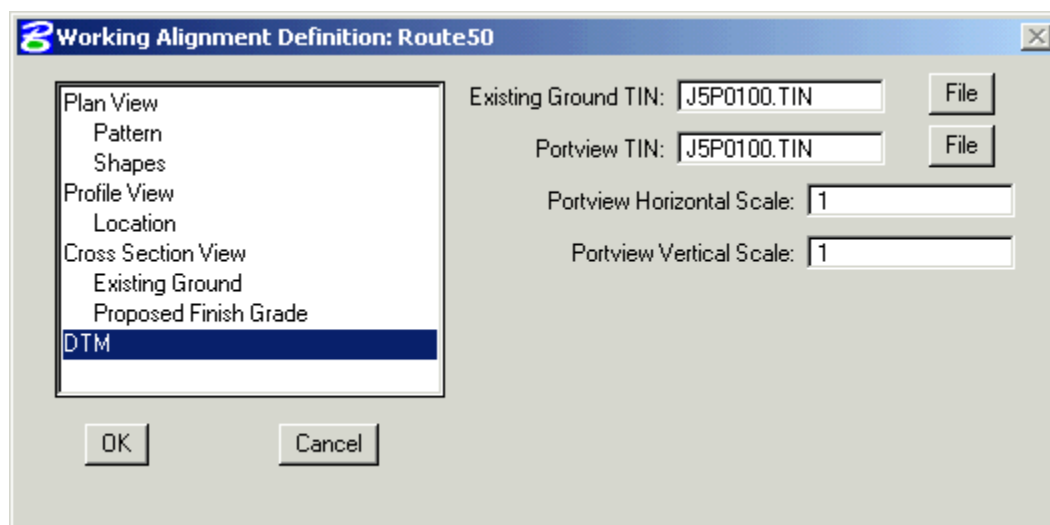
Copy the MoDOT Working Alignment to **Route50**, and select the **Route50** working alignment.



10. Set the **DTM** section of the **Working Alignment Definition** (Define button)

Set the **Existing Ground TIN** and **Portview TIN** to  
**t:\de-proj\cole\j5p0100\data\j5p0100.tin**

Set the **Portview Horizontal** and **Vertical Scales** to **1**.

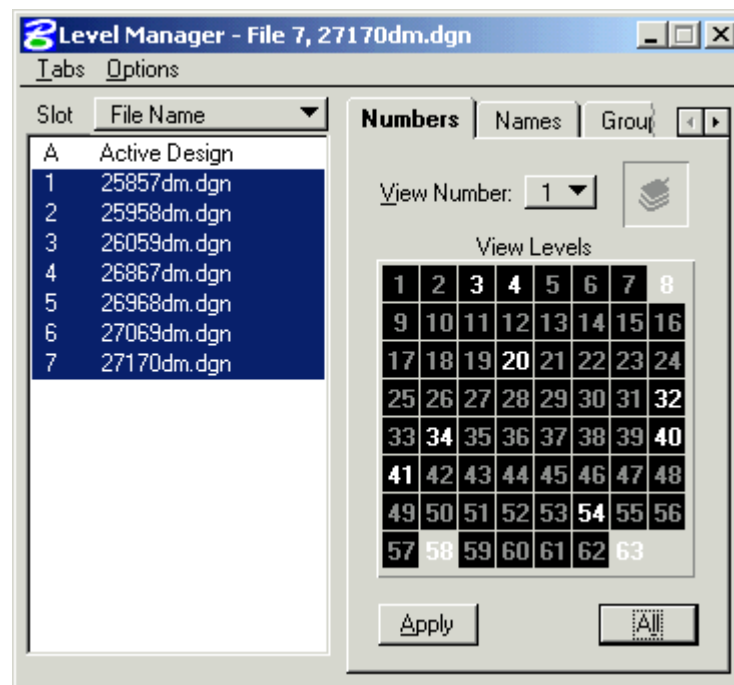


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11. Reference (MicroStation menu **File > Reference** or **REF** icon) the photogrammetric files to **topo\_j5p0100.dgn**:

25857dm.dgn  
25958dm.dgn  
26059dm.dgn  
26867dm.dgn  
26968dm.dgn  
27069dm.dgn  
27170dm.dgn

Open the **MicroStation Level Manager**; highlight the attached reference files; and **turn off** levels 8, 58, and 63 as shown below.



Save the changes to the MicroStation file.

12. Exit Project Manager by going to the Road Project pull down menu **File > Exit**.

